# Summer 2014 Pathways Report

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This summer, I completed my second Pathways rotation in NE-F2: Fluids and Propulsion Design Branch in the Engineering Directorate. A couple weeks ago, I completed my Student Showcase describing my main project this summer, some of the other projects I've done in previous internships, and my future goals. I plan on returning to school this fall and completing my Bachelor's degree in Aerospace Engineering this December. I will then be ready to be converted to a full time position here at Kennedy Space Center. I also plan on going on to graduate school and obtaining a Master's degree in Engineering Physics or Space Science and possibly a Ph. D.

My main job this summer was on Ground Operations and Demonstration Unit for Liquid Oxygen (GODU LO2). GODU LO2 is one of many of the Cryogenics Test Lab's (CTL) technology development projects. It mimics a typical launch pad liquid oxygen (LO2) propellant system in order to improve efficiency in loading operations. It consists of a storage tank, a vehicle tank, as well as a series of pumps and control valves to pump liquid nitrogen (LN2) from the storage tank into the vehicle tank. Test engineers use liquid nitrogen (LN2) instead of LO2 because LN2 is much less reactive and less hazardous than LO2, and they both have about the same temperature and density.

In a typical test at GODU LO2, LN2 is pumped from the storage tank and into the vehicle tank. Various sensors are installed in the piping along the way so test engineers can measure pressure, temperature, flow rate, loss, and other variables. After each test, LN2 is drained from the vehicle tank and onto the ground, where it would boil off into the atmosphere. In an attempt to conserve LN2, a "recirculation" line was added, so that LN2 could flow back into the storage tank. However, with the current vehicle tank purge system, LN2 was flowing so fast through the "recirculation" line that the purge system could not keep up. Test engineers had to stop the LN2 flow and wait for the purge system to raise the pressure so that a vacuum would not form in the vehicle tank. One of my mentors hoped to fix this problem by tapping in on a higher pressure line and adding an orifice and a manual valve.

My job was to first modify the GODU LO2 schematic in Creo Parametric. I then needed to determine if an orifice was needed and to size it if it was needed. If something in the system got clogged and the pressure rose above the design pressure, the relief valve would actuate and protect the vehicle tank from over pressurizing. However, if the flow during actuation was too much, pressure behind the relief valve could continue to rise and the vehicle tank would still be

in danger of over pressurizing. The orifice would limit the flow into the vehicle tank so that the relief valve would indeed depressurize the vehicle tank if needed.

I then needed to make sure that the purge system could really fix the problem, and that it would be able to maintain a constant pressure in the vehicle tank while LN2 was flowing out of it. I did this by creating three models in AFT (Advanced Flow Technology) Arrow and Fathom software. I created a model of the purge system, one of the liquid nitrogen system, and the other of the vent system. For this, I had to make many tedious measurements out in the field of pipe lengths, valve elevations, and number of tees and elbows. I also had to find spec sheets for every fluid component so that I knew how each component affected the flow. Once I acquired all the data I needed, I iterated my three models together and solved for pressures in the two tanks and volume flow rate throughout the entire system. I noticed that there was a solenoid valve in the purge system that had a low $C_v$ value (high pressure loss), and so I suggested to replace it in order to maximize flow rate. I presented my findings and suggestions to a cryogenics test engineer and wrote a report. Figure 1 shows me with GODU LO2.


**Figure 1: Me with GODU LO2**

This summer I also participated in a few odd jobs. One of these jobs was to correct a fluid schematic for one of the gaseous nitrogen (GN2) panels at the Cryogenics lab. My supervisor handed me a piece of paper of the schematic with many corrections made with red pen. My job was to make the corrections in Creo Schematic Software. I learned a lot about different kinds of valves and what all the symbols for different valves and components on fluid schematics mean. I also learned how to use Creo Schematic.

Another job introduced me to Pressure Vessel and Systems (PVS) certification and how to make sure all the components within a system are safe. The project I worked on was GODU for liquid hydrogen (LH2). This job required me to find spec sheets on fluid components such as pumps, filters, valves, expansion joints, flex hoses, etc. and make sure that the design conditions did not go outside the components' specifications (i.e. we don't want to put 6000 psi through a valve rated for only 35 psi!).

My mentor spent over half the summer preparing for a vaporizer test that occurred on July 10th. This LO2 vaporizer would pressurize the oxygen tank and help pump LO2 into the SLS vehicle on the launch pad. Again, LN2 was used for this test because it is much safer and less reactive than LO2. My mentor needed to see if one vaporizer would be sufficient or if two were needed. The test involved flowing four tankers of LN2 through a vaporizer to see if one vaporizer would vaporize the LN2 fast enough. I had the opportunity to observe the test. Unfortunately, I was so involved in the GODU LO2 project that I didn't have much time to do any other work on this project. However, I did learn how the vaporizer worked: LN2 flows into a boiler, then into a separator where the LN2 boils into GN2. The GN2 flows into a heat exchanger, similar to the boiler. Then the high pressure GN2 rushes out of the vent and into the atmosphere. On launch day, the high pressure gaseous oxygen from the vaporizer would flow into the top of the LO2 spherical tank and push down on the LO2 surface. The high ullage pressure in the oxygen tank aides the pumps in pushing the LO2 up into the rocket on the launch pad.

**Figure 2: Vaporizer test from atop LO2 tank at launch pad**

Two significant events for me this summer were the Intern Social and Senior Management Networking day at the park and the Student Showcase. I thought the day at the park with senior management was a unique experience and a really creative idea. I thought it was really inspiring to talk with one of the senior management personnel and to hear his story. I also really enjoyed the team exercise where each division chose numbers and letters so that they would earn points. I learned that the definition of "winning" may not always be so obvious, and that sometimes it's best to let everyone have an equal share in the work as well as an equal share in the reward.

The other significant event for me was the Student Showcase. I had the opportunity to present this summer. Although I was a little nervous, I was excited to share all that I've worked on during my past and present internships. It required a lot of practice, but it paid off because I think it went really well.